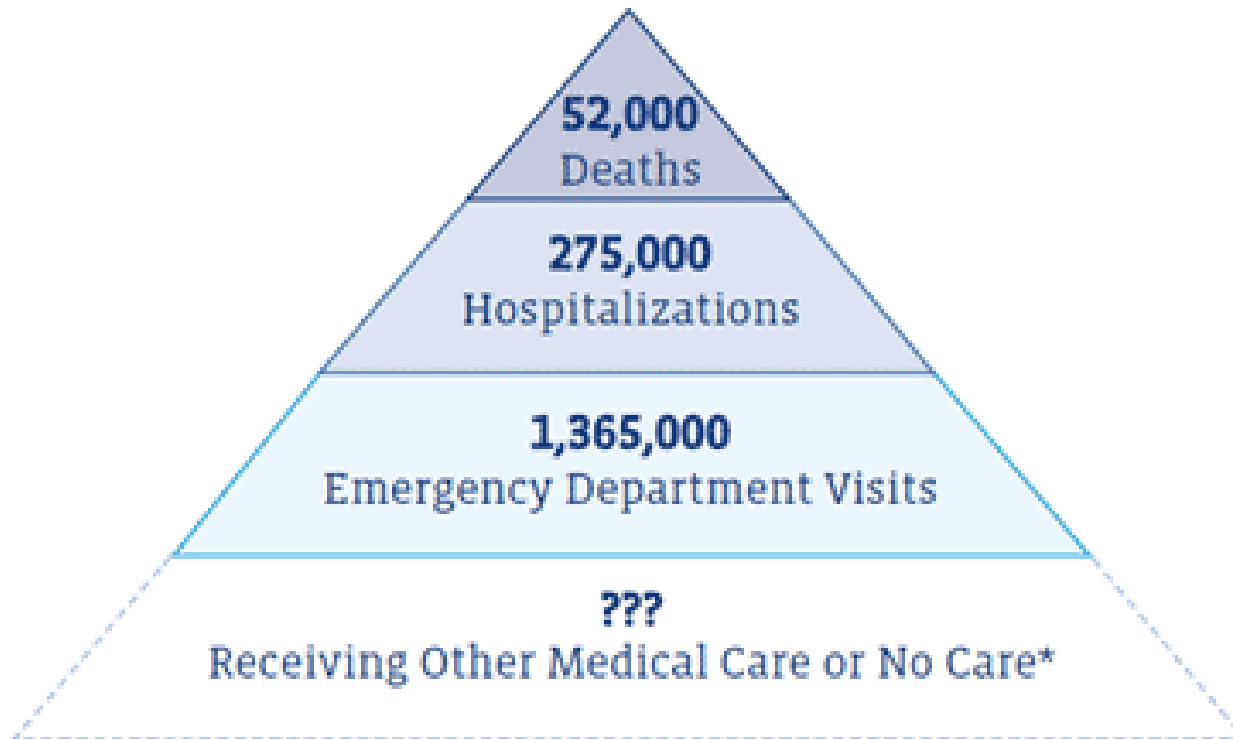


Signs and Symptoms of Traumatic Brain Injury

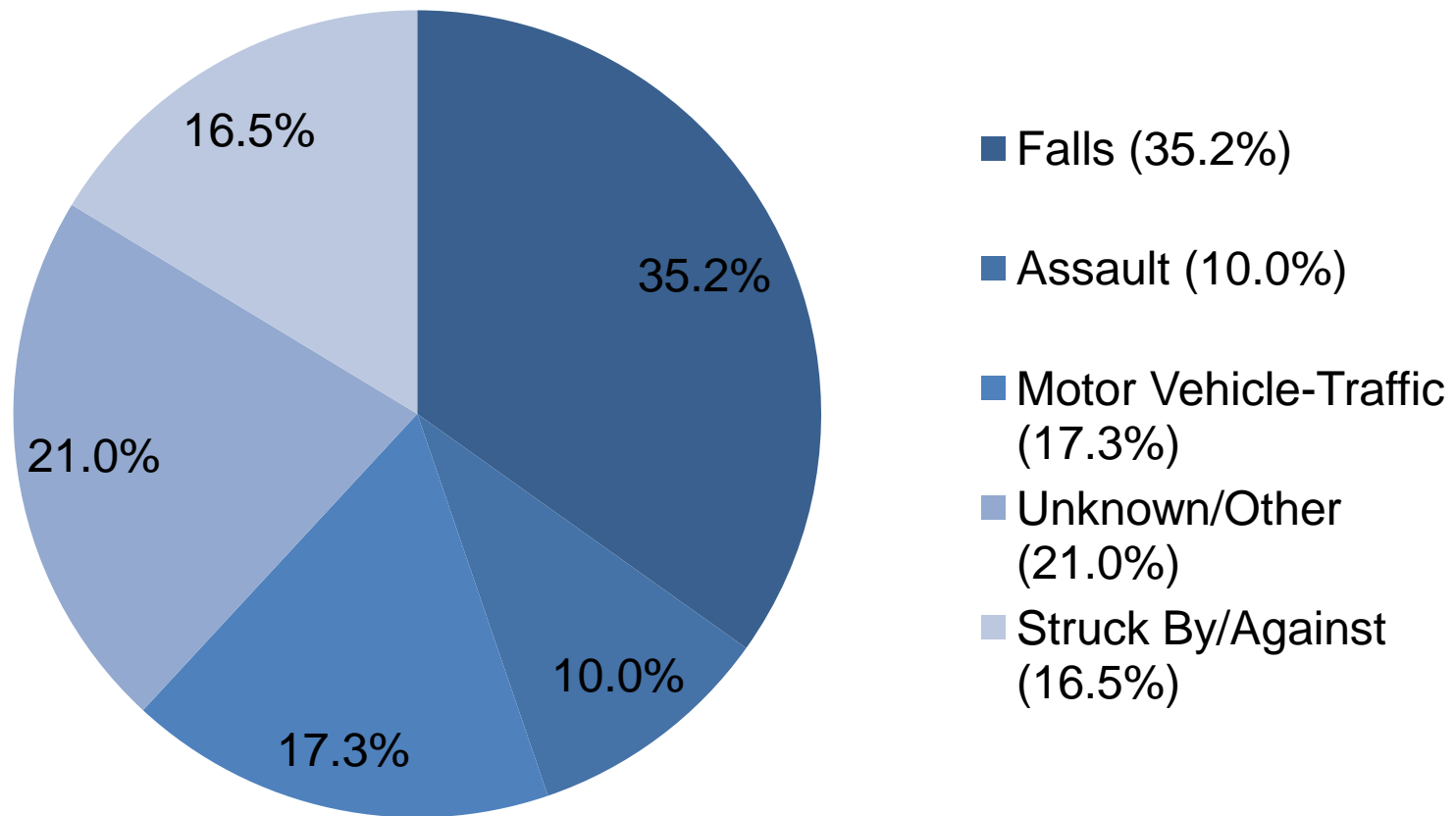
James P. Kelly, MA, MD, FAAN
Director
National Intrepid Center of Excellence

Estimated Average Annual Number of TBI in the United States 2002-2006



Content source: [Centers for Disease Control and Prevention](#), [National Center for Injury Prevention and Control](#)

Estimated Average Percentage of Annual TBI by External Cause in the United States 2002-2006



Concussion: Definition

Concussion: A clinical syndrome characterized by immediate and transient impairment of neural function, such as alteration of consciousness, disturbance of equilibrium, etc., due to mechanical forces.

Ad hoc Committee to Study Head Injury Nomenclature, Congress of Neurological Surgeons, 1964

MTBI Definitions

- Prior to 1991 definitions from TBI Data Bank:
 - GCS 13-15, PTA [post traumatic amnesia] <24 hours, LOC [loss of consciousness] <20 minutes

- MTBI Committee of the Head Injury Special Interest Group of ACRM added:
 - Any alteration in mental state at the time of injury (dazed, disoriented or confused)

Glasgow Coma Scale

➤ *Motor*

- Obeys – 6
- Localizes – 5
- Normal flexion/withdraws – 4
- Abnormal flexion (decort) – 3
- Extension (decerebrate) – 2
- No response – 1

➤ *Verbalization*

- Orientated – 5
- Confused – 4
- Inappropriate words – 3
- Incomprehensible sounds – 2
- No response – 1

➤ *Eye Opening*

- Spontaneously – 4
- To voice – 3
- To pain – 2
- No response – 1

Mild Traumatic Brain Injury

- Concussion – an alteration in mental status caused by biomechanical forces that *may or may not produce unconsciousness*
- Hallmarks are confusion and amnesia
- Accounts for about 80 % of all hospitalizations for brain injury
- 15 % of MTBI have disabling symptoms after 1 year

Common Early Symptoms of Concussion

- Headache
- Dizziness, lightheadedness or vertigo
- Lack of awareness of surroundings
- Muddled thinking
- Nausea and vomiting

Common Late Symptoms of Concussion

- Persistent headache
- Lightheadedness
- Decreased attention and concentration
- Poor memory
- Easy fatigability
- Irritability
- Anxiety or depressed mood
- Sleep disturbance

Signs of Concussion

- Vacant stare (dazed, befuddled facial expression)
- Delayed responses (slow to answer questions or follow instructions)
- Inattention (easily distracted or unable to track conversations)
- Disorientation (walking in the wrong direction, unaware of time, date, place)
- Slurred or incoherent speech (making disjointed or incomprehensible statements)

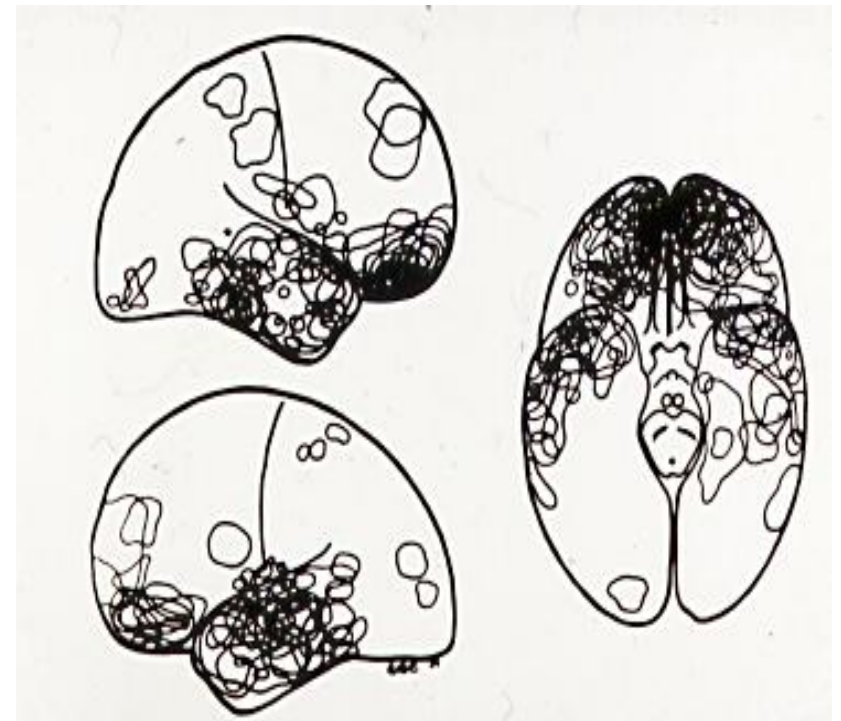
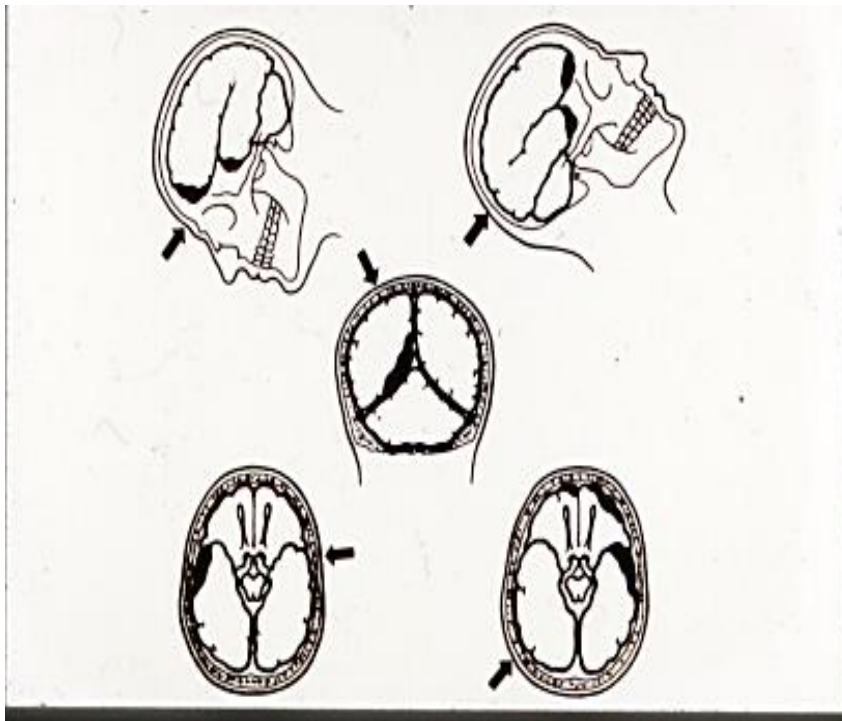
Signs of Concussion, continued

- Incoordination (stumbling, inability to walk tandem/straight line)
- Inappropriate emotionality (appearing distraught, crying for no apparent reason)
- Memory problems (exhibited by athlete repeatedly asking a question that has already been answered or exhibiting memory deficits on mental status testing)
- Loss of consciousness (paralytic coma, unresponsiveness to stimuli)

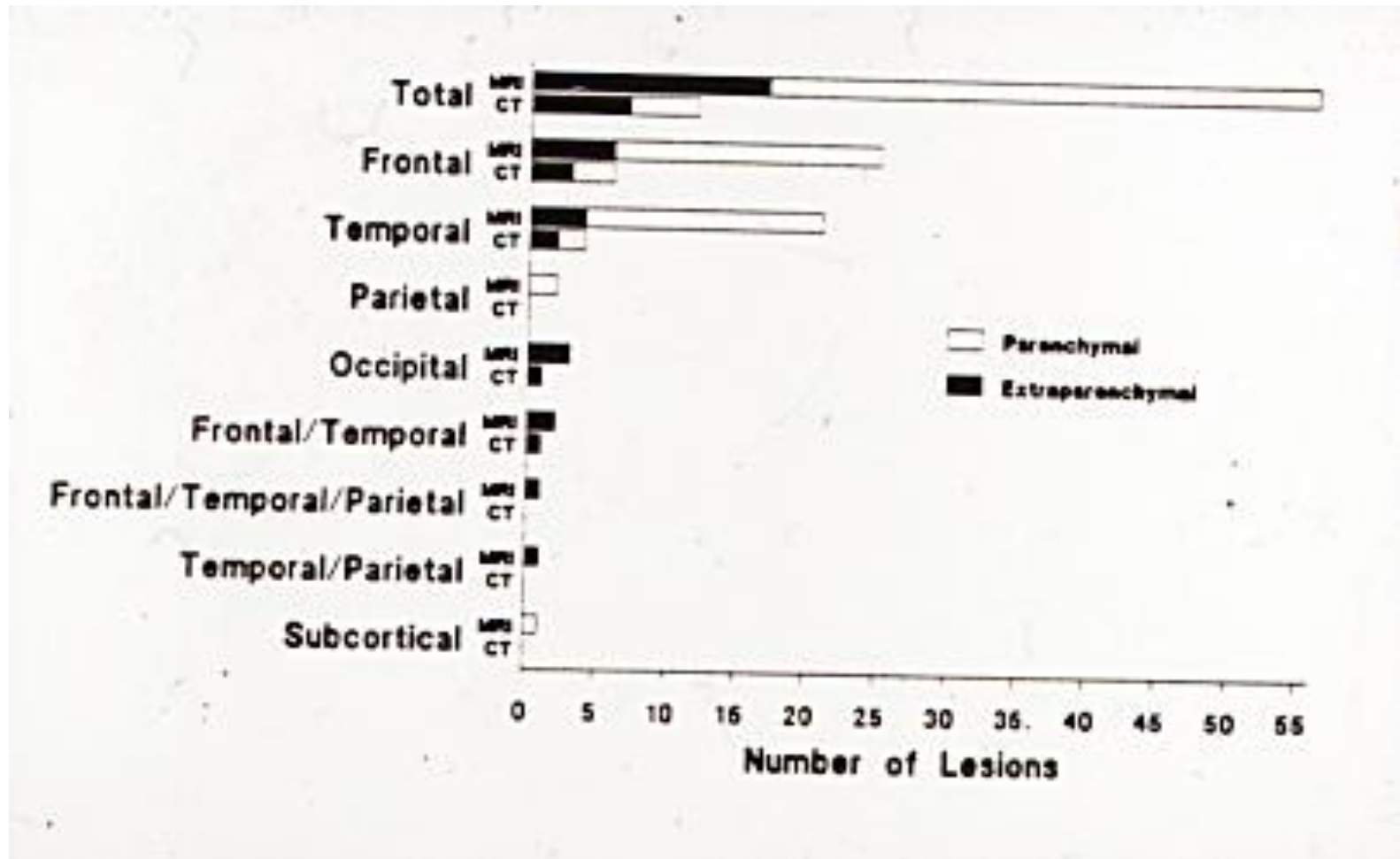
- LOC more than 30 minutes is no longer considered *Mild TBI* (Mild TBI Special Interest Group – ACRM, 1993)
- Athletes rendered unconscious for more than 5 minutes are considered neurosurgical emergencies (Alves & Polin, 1996)

Biomechanics - 1

- Regardless of the direction of the force, frontal & temporal lobes are most affected

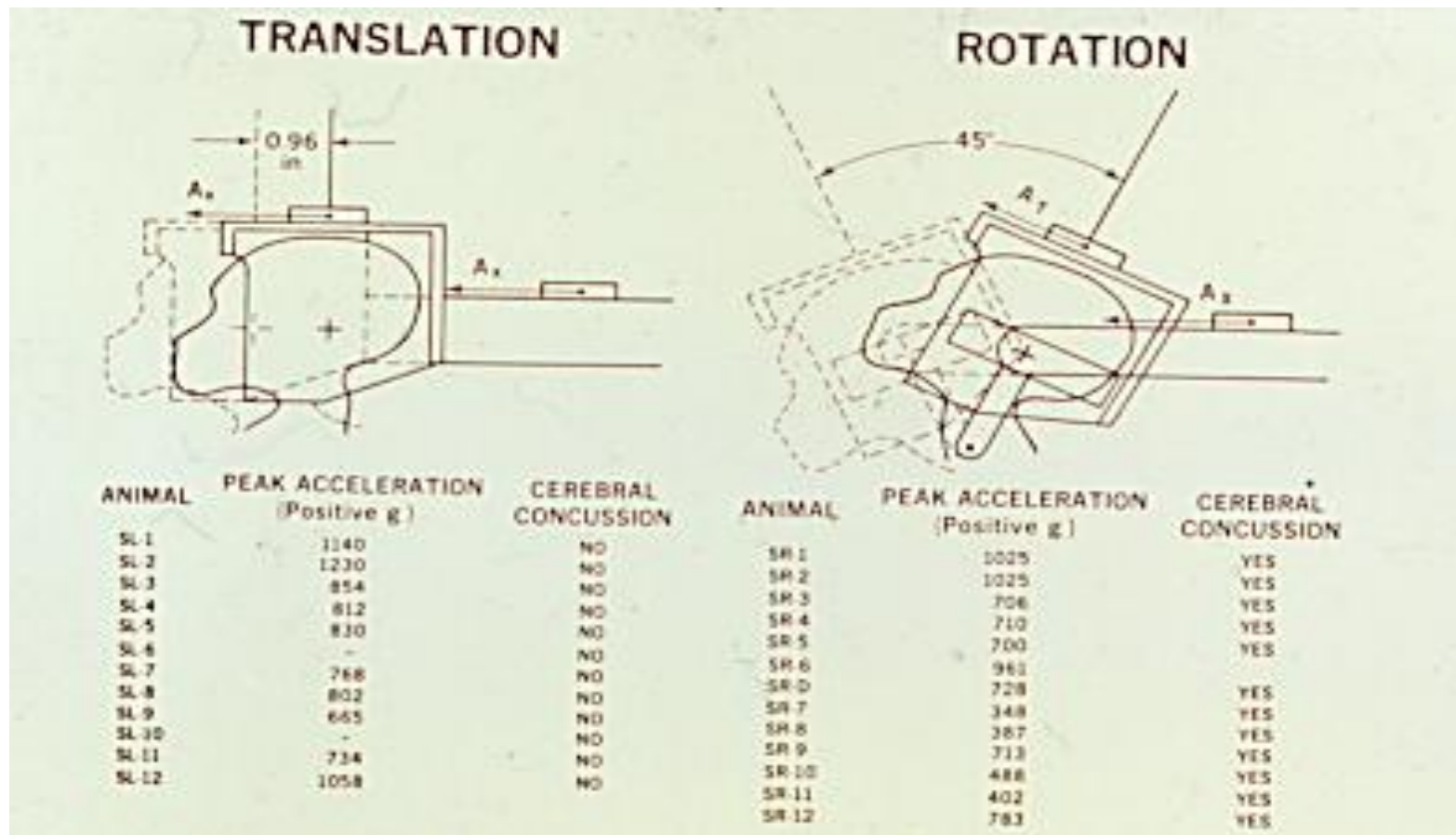


Biomechanics - 2



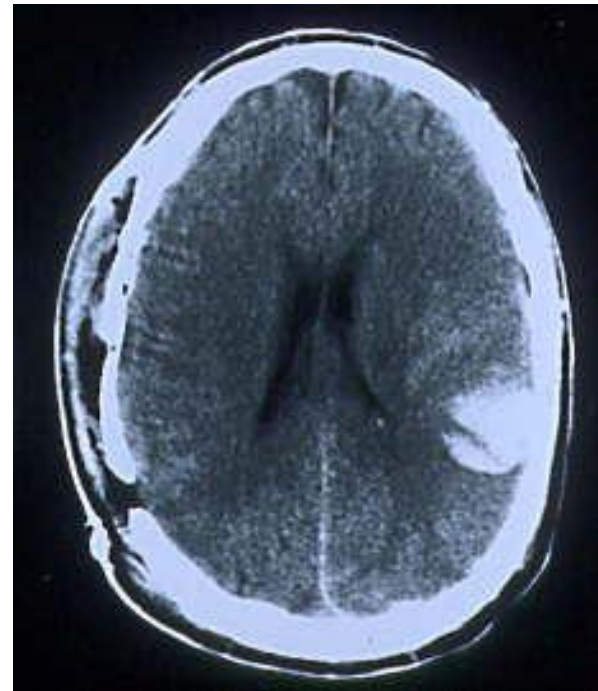
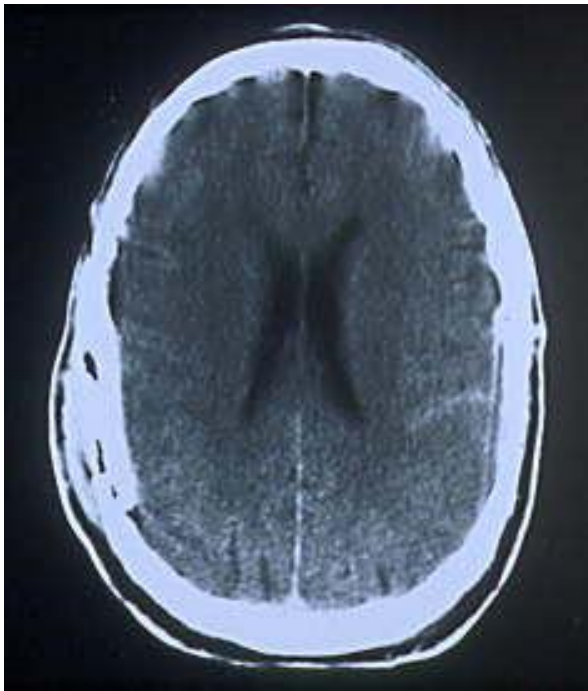
Biomechanics - 3

- Rotational (angular) forces are more damaging than Translational (linear)



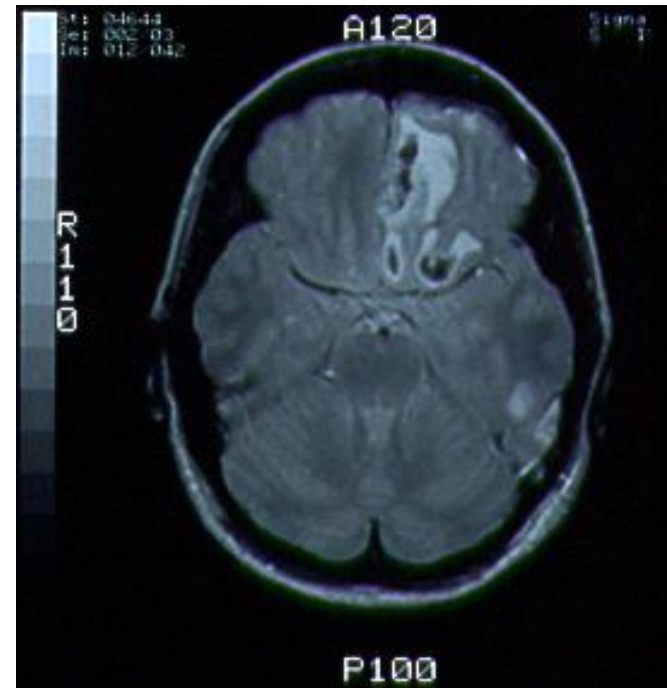
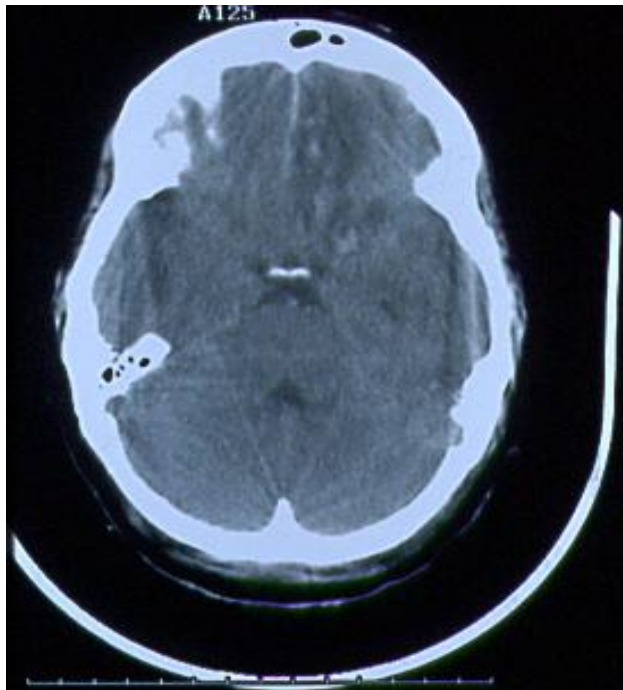
Biomechanics - 4

- Linear (translational) forces also cause skull fractures and contrecoup contusions

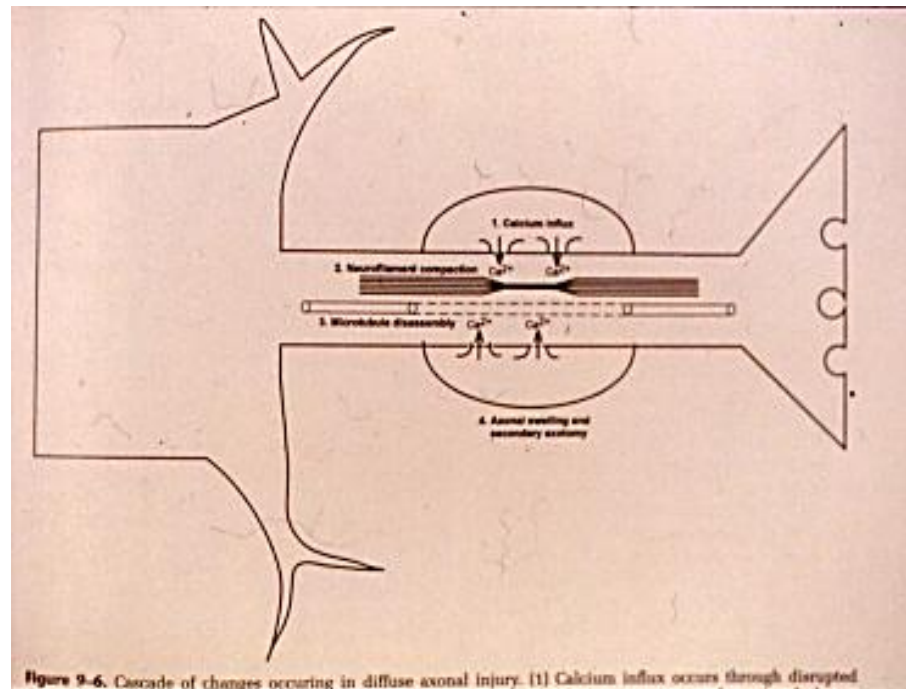


Contrecoup Injury

- Superiority of MRI over CT for detecting brain lesions

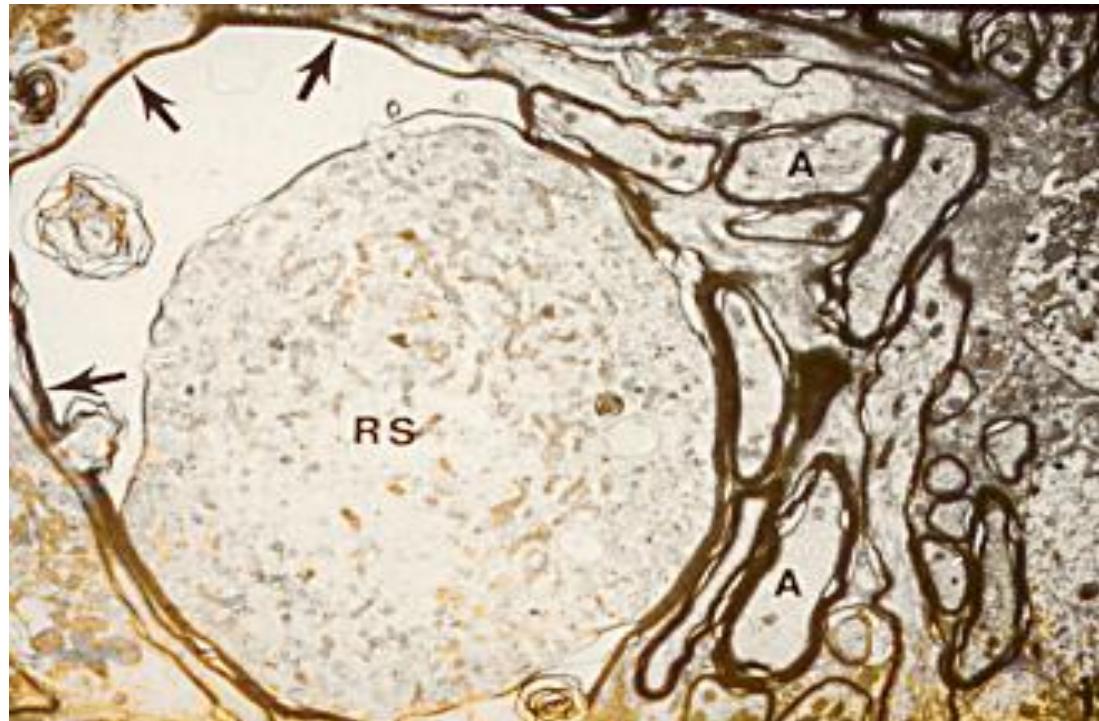


- Na – K pump failure and axonal stretch injury lead to Calcium influx and axonal swelling or disintegration

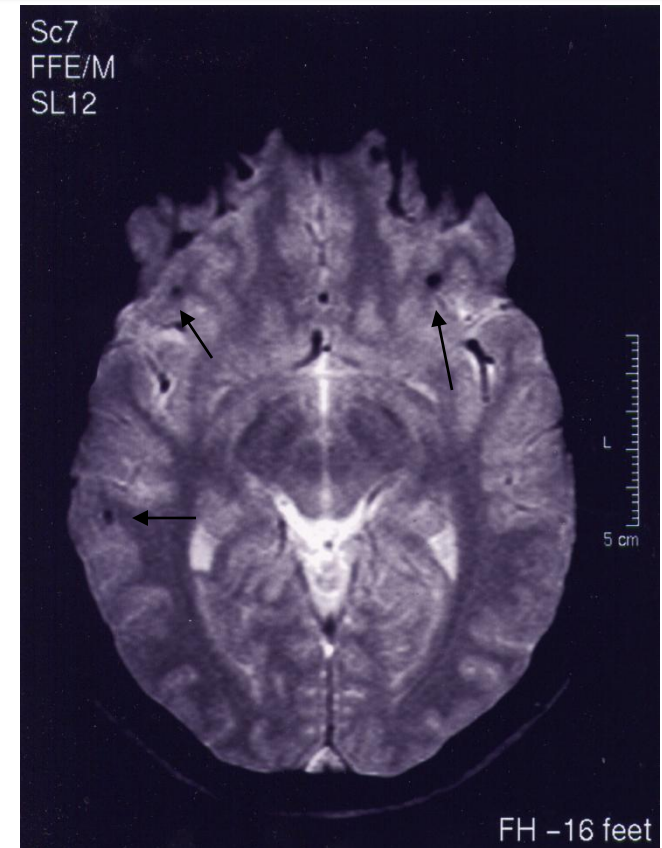
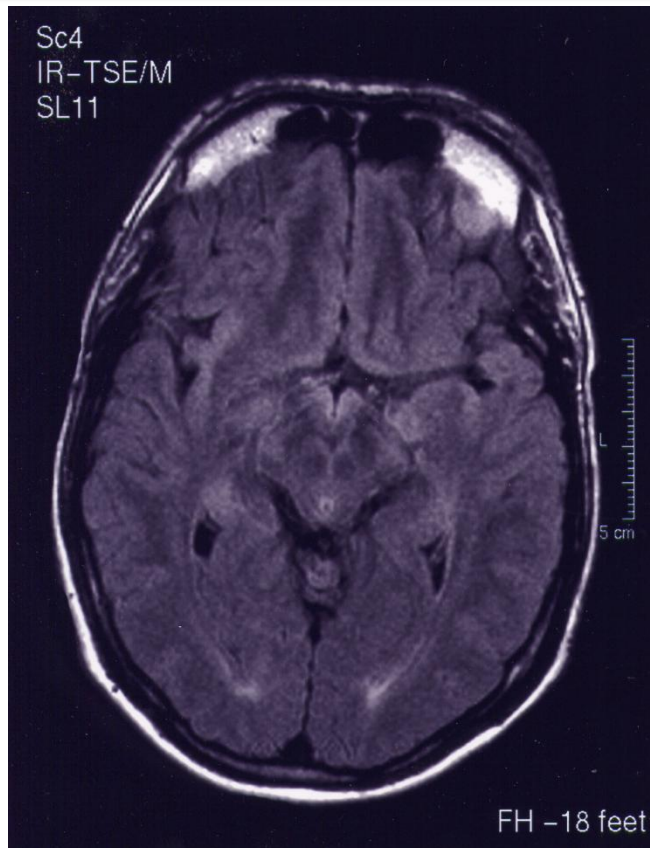


Pathophysiology

- Rotational injuries lead to diffuse shearing of small vessels
- Diffuse axonal injury is underlying lesion

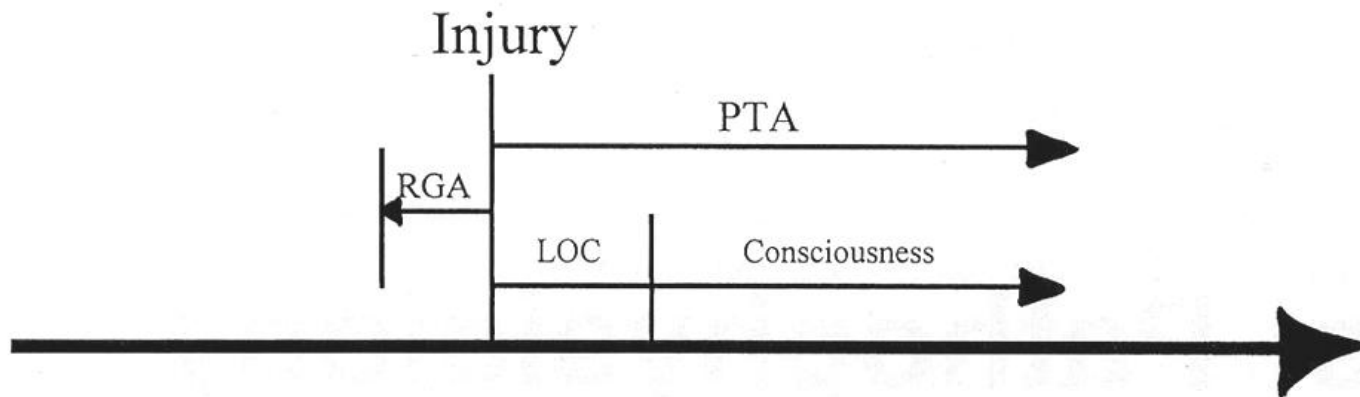


Shearing Injury



- Standard MRI and gradient echo MRI of a 27 year old hockey player after a single concussion.

RGA - LOC - PTA

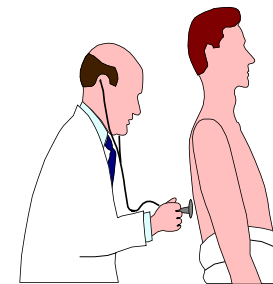
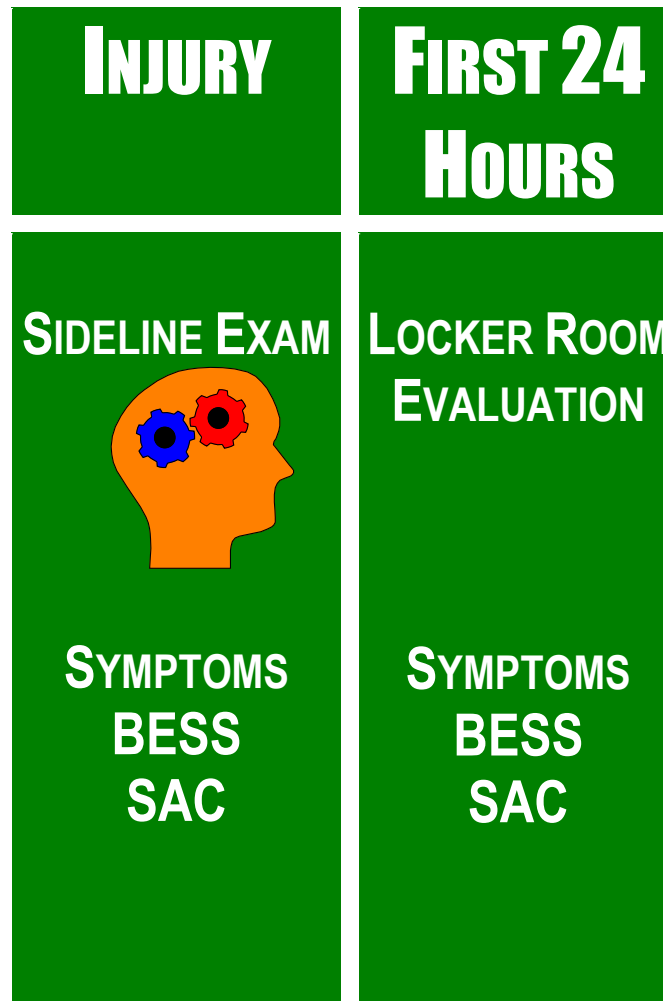


Time course of concussion. RGA = retrograde amnesia, LOC = loss of consciousness, PTA = posttraumatic amnesia.

Standardized Assessment of Concussion - SAC

- Standardized mental status examination
- Composite Total Score (30 pt. Scale)
- Neurocognitive Domains
 - Orientation, Concentration, Immediate/Delayed Memory
- Neurologic screening
- Exertion/provocative maneuvers
- Alternate forms A, B, C
- Brief: 5-7 Minutes to administer

Concussion in Sports: Assessment Model



Standardized Assessment of Concussion – Form A

SAC
Standardized Assessment of Concussion
FORM A

Name: _____
Age: _____ Sex: _____ Examiner: _____
Nature of Injury: _____
Date of Exam: _____ Time: _____ Exam No. _____

1) ORIENTATION:

Month: _____ 0 1
Date: _____ 0 1
Day of week: _____ 0 1
Year: _____ 0 1
Time (within 1 hr.): _____ 0 1
Orientation Total Score _____ / 5

2) IMMEDIATE MEMORY: (all 3 trials are completed regardless of score on trial 1 & 2; score equals sum across all 3 trials)

List	Trial 1	Trial 2	Trial 3
Elbow	0 1	0 1	0 1
Apple	0 1	0 1	0 1
Carpet	0 1	0 1	0 1
Saddle	0 1	0 1	0 1
Bubble	0 1	0 1	0 1
Total			

Immediate Memory Total Score _____ / 15
Note: Do not inform the subject that delayed recall will be tested.

NEUROLOGICAL SCREENING:

Loss of Consciousness (presence, duration)

Recollection of injury (pre- or post-traumatic amnesia)

Strength:

Sensation:

Coordination:

3) CONCENTRATION:

Digits Backward: (If correct, go to next string length. If incorrect, read trial 2. Stop after incorrect on both trials)

4-9-3	6-2-9	0 1
3-8-1-4	3-2-7-9	0 1
6-2-9-7-1	1-5-2-8-6	0 1
7-1-8-4-6-2	5-3-9-1-4-8	0 1

Months in Reverse Order: (entire reverse sequence correct for 1 pt.)
Dec-Nov-Oct-Sep-Aug-Jul
Jun-May-Apr-Mar-Feb-Jan 0 1
Concentration Total Score _____ / 5

EXERTIONAL MANEUVERS
(when appropriate):

5 jumping jacks	5 push-ups
5 sit-ups	5 knee-bends

4) DELAYED RECALL:

Elbow	0 1
Apple	0 1
Carpet	0 1
Saddle	0 1
Bubble	0 1
Delayed Recall Total Score	_____ / 5

SUMMARY OF TOTAL SCORES:

Orientation	_____ / 5
Immediate Memory	_____ / 15
Concentration	_____ / 5
Delayed Recall	_____ / 5
Overall Total Score	_____ / 30

©Copyright McCrea, Kelly, Randolph 1998

SAC Clinical Validity Study

Neurosurgery, May, 2001

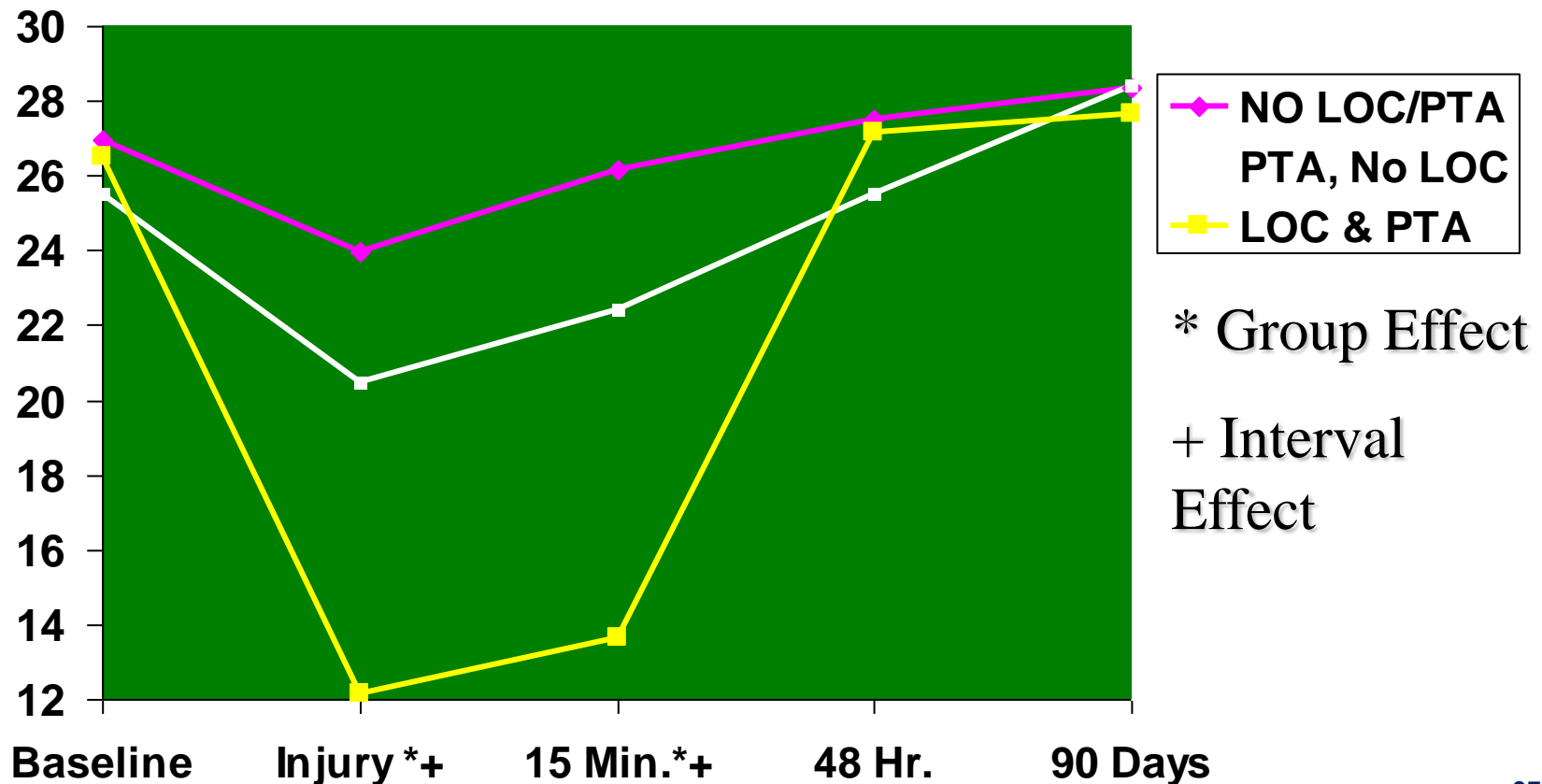
- 2,382 HS & College football players studied
- 30 High Schools, 8 Colleges/Universities
- Baseline Protocol: 1,187 subjects
- No Baseline Protocol: 1,195 subjects
- 91 Injuries (3.8%): 45 BL, 46 No BL
- Injuries: 58 HS (3.3%); 33 College (5.2%)
- Assessment at Injury, 15 min., 48 hours, 90 days
- Groups by LOC, PTA, Neither

Effects of LOC and PTA

- 91 Injured Subjects
- 83.5 % (n=76) with NO PTA or LOC
- 8.8% (n=8) with PTA and NO LOC
- 7.7% (n=7) with PTA and LOC
- No Subjects with LOC but no PTA
- LOC and PTA: brief, seconds to minutes
- PTA/LOC correlate with cognitive indicators
- Course of Recovery by clinical groups

SAC Total Score: LOC vs PTA

Baseline, Concussion, and Follow-Up



Concussion Grading Scales

Colorado, 1991

- Grade I: Confusion Only
- Grade II: Amnesia (PTA or RGA), no LOC
- Grade III: LOC

Concussion Grading Scales

American Academy of Neurology, 1997:

- Grade 1: Transient confusion, no LOC, abnormalities resolve in less than 15 minutes
- Grade 2: Transient confusion, no LOC, abnormalities last greater than 15 minutes
- Grade 3: Loss of consciousness is (a) Brief [seconds] or (b) Prolonged [minutes]

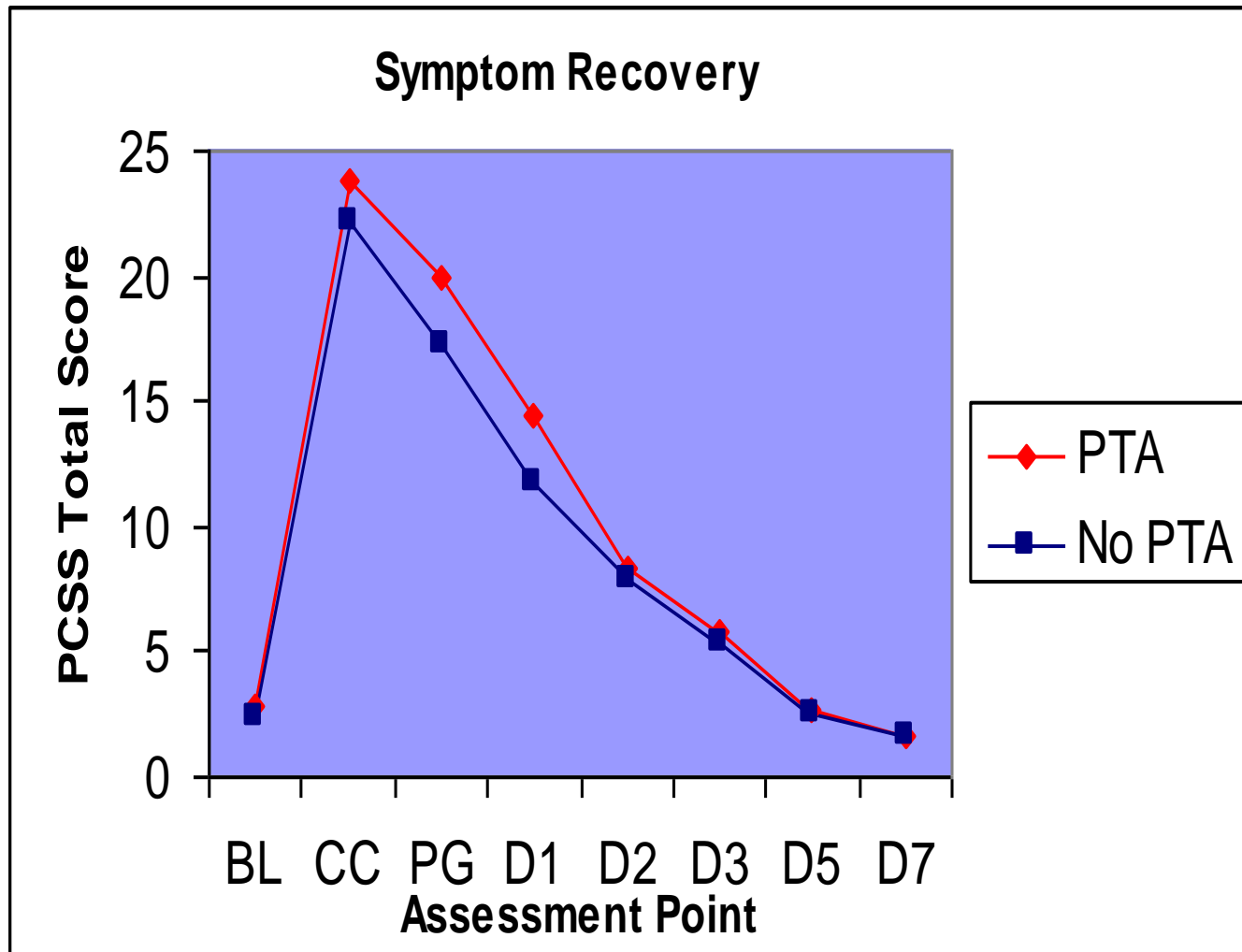
Principles of Withholding from Play

- “Resting” the brain
- Protecting against any further chance of concussion
- Gradual re-entry to sport

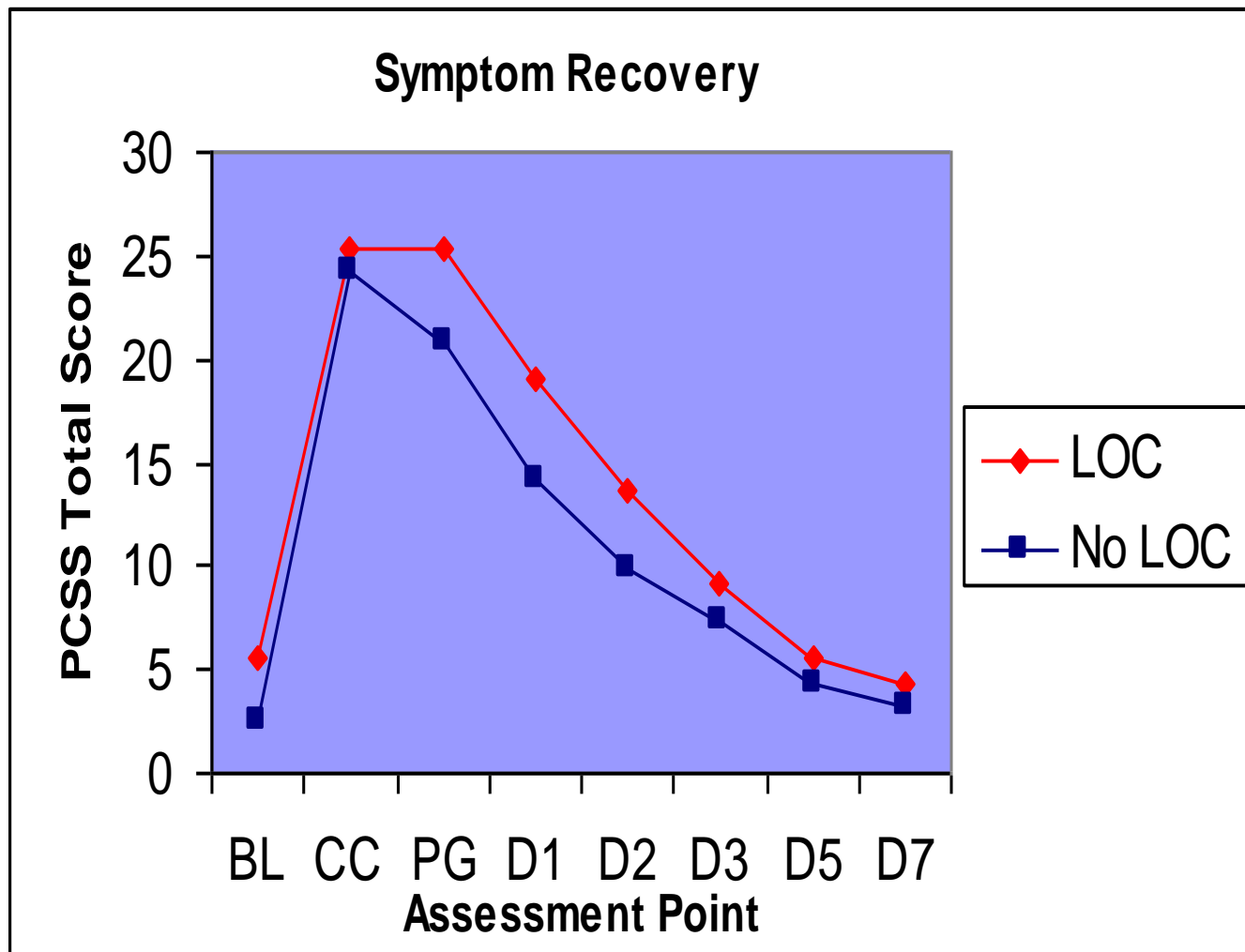
Graded Symptom Checklist Scores

77 PTA & 226 No PTA

(Concussed HS & Collegiate Athletes)



Graded Symptom Checklist Scores 23 LOC & 280 No LOC (Concussed HS & Collegiate Athletes)

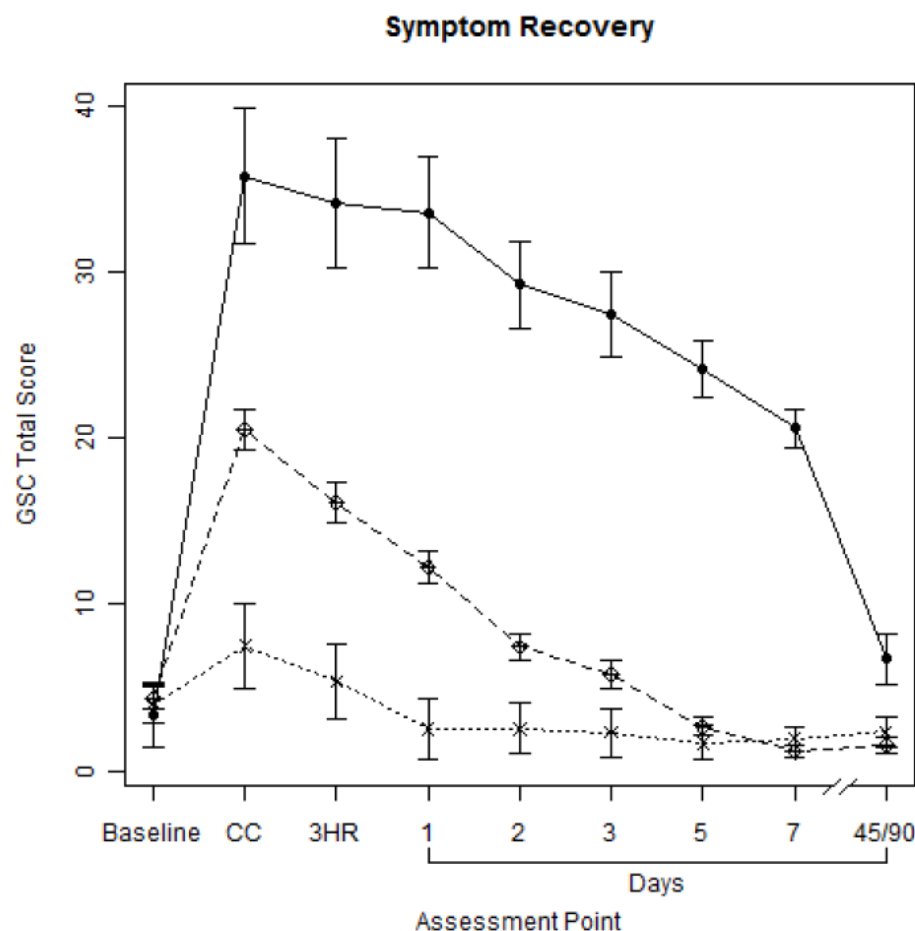
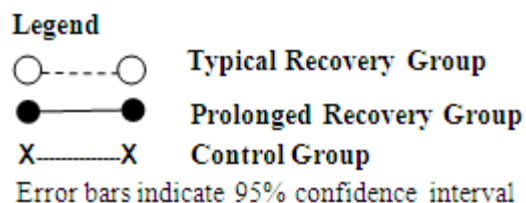


Prolonged Concussion Recovery

Figure 1. Symptom Recovery Curve Comparing Typical Recovery, Prolonged Recovery and Normal Control Groups.

- Group x time interaction, $p < 0.001$
- Higher scores indicate more severe symptoms on the GSC
 - GSC=Graded Symptom Checklist; CC=time of concussion; 3 HR=3 hours postinjury.

- Error bars indicate 95% confidence interval



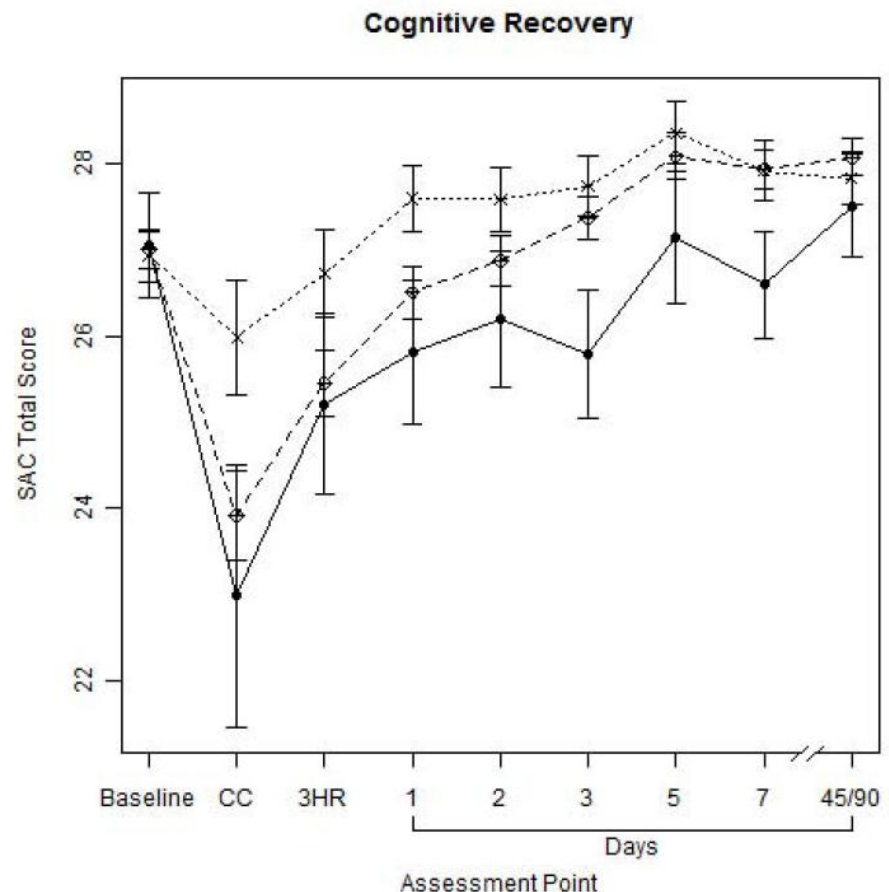
Prolonged Concussion Recovery

Figure 2. Cognitive Recovery Curve Comparing Typical Recovery, Prolonged Recovery and Normal Control Groups.

- Group x time interaction, $p < 0.001$
- Lower scores indicate poorer cognitive test performance on the SAC.
 - SAC=Standardized Assessment of Concussion;
 - CC=time of concussion; 3 HR=3 hours postinjury.
- Error bars indicate 95% confidence interval

Legend

○-----○ Typical Recovery Group
●-----● Prolonged Recovery Group
X-----X Control Group
Error bars indicate 95% confidence interval



Prolonged Concussion Recovery

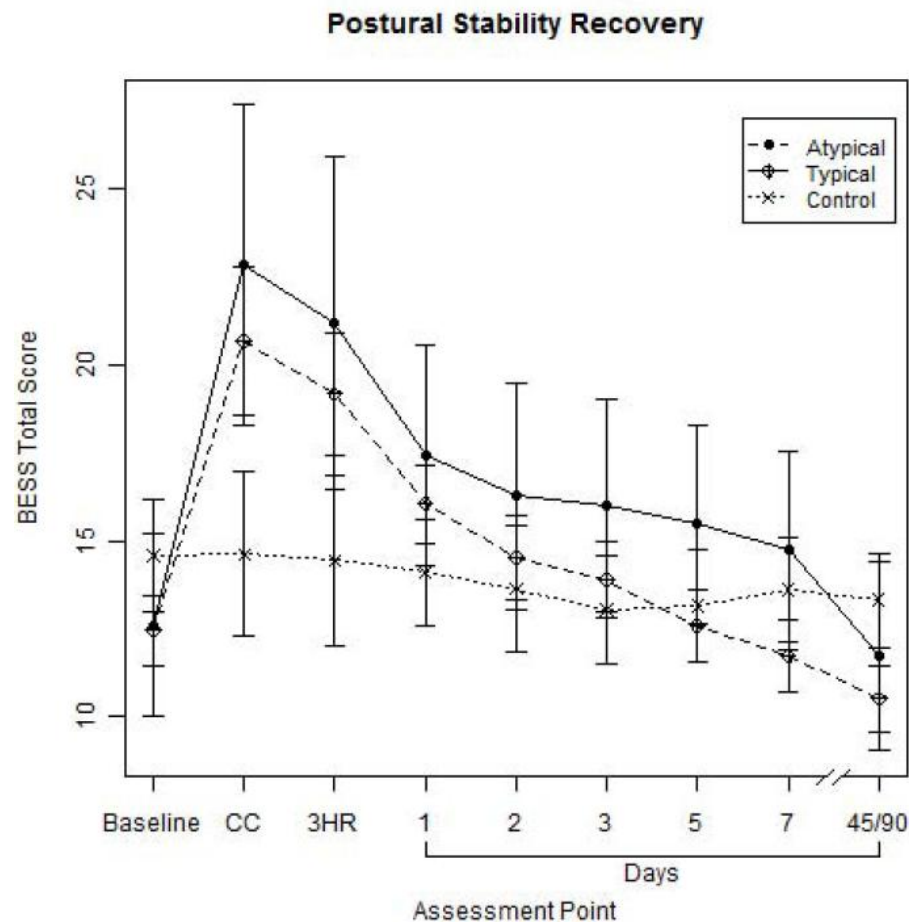
Figure 3. Postural Stability Recovery Curve Comparing Typical Recovery, Prolonged Recovery and Normal Control Groups.

- Group x time interaction, $p < 0.001$
- Higher scores indicate poorer balance test performance on the BESS.
 - BESS=Balance Error Scoring System; CC=time of concussion; 3 HR=3 hours postinjury.
- Error bars indicate 95% confidence interval

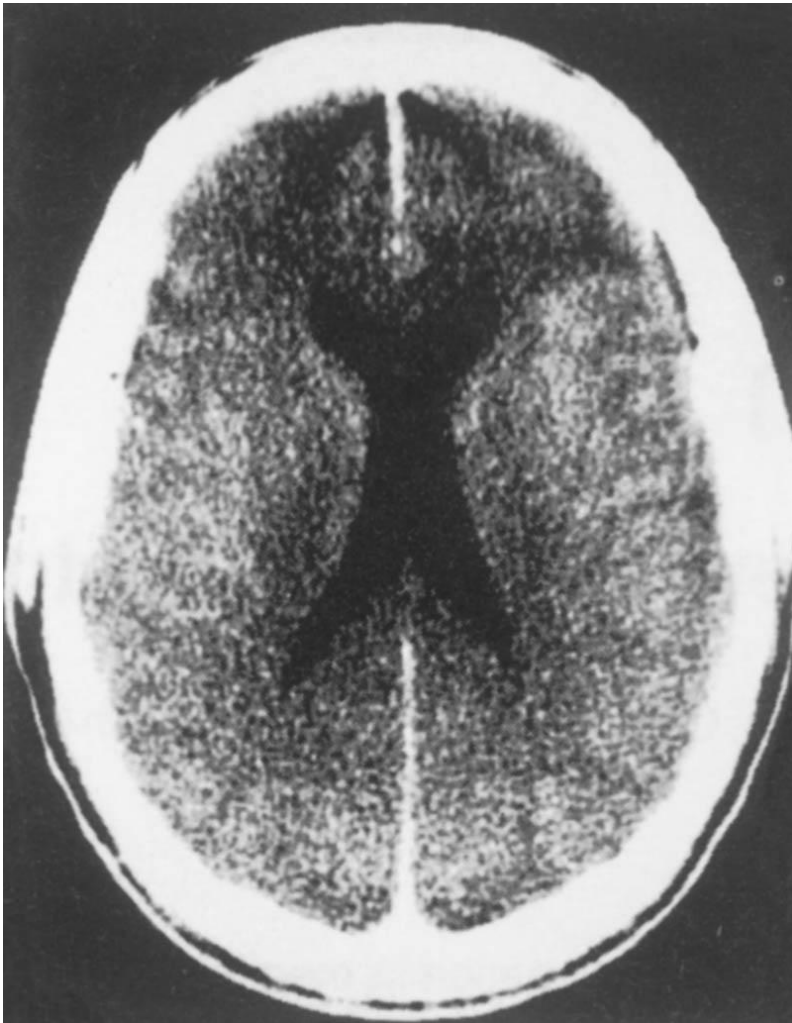
Legend

- Typical Recovery Group
- Prolonged Recovery Group
- X-----X Control Group

Error bars indicate 95% confidence interval



Second Impact Syndrome



CT scan of a high school football player in coma after two concussions one week apart.

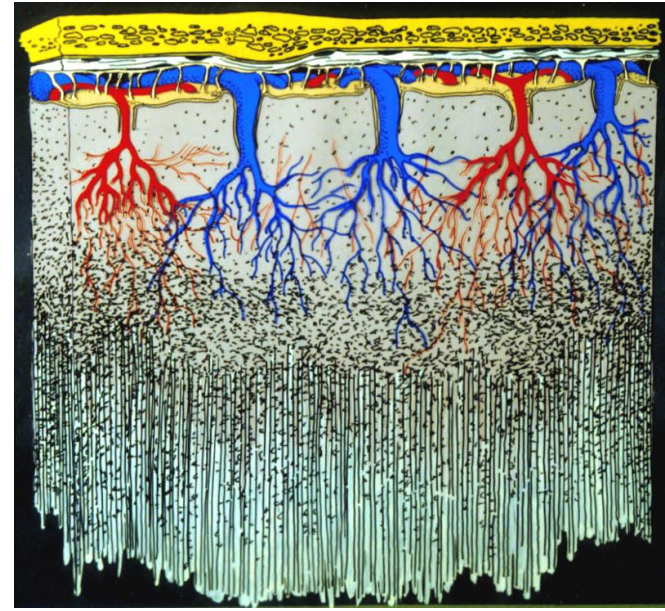
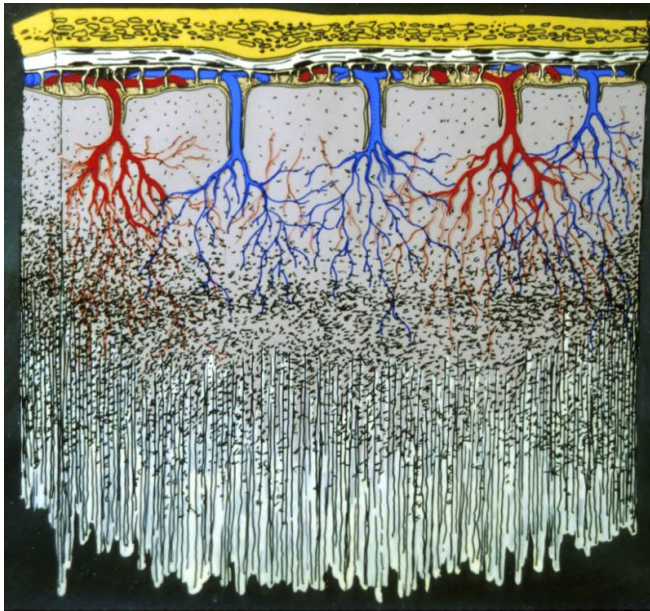


NICoE
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Center of Excellence

-
- This anatomical illustration depicts the venous drainage system of the head. The upper portion shows a cross-section of the scalp layers, including the skin, subcutaneous tissue, and galea, with various veins and arteries labeled. The lower portion shows a lateral view of the head with the scalp reflected, revealing the underlying skull and the complex network of dural venous sinuses, such as the superior sagittal sinus, transverse sinus, sigmoid sinus, jugular vein, and internal carotid artery.

Second Impact Syndrome

- Catastrophic brain swelling occurring if concussions happen near each other in time.
- Intracranial vasodilation and cerebrovascular congestion – vascular autoregulation dysfunction



Traumatic Brain Injury

Explosions



Blast Injury



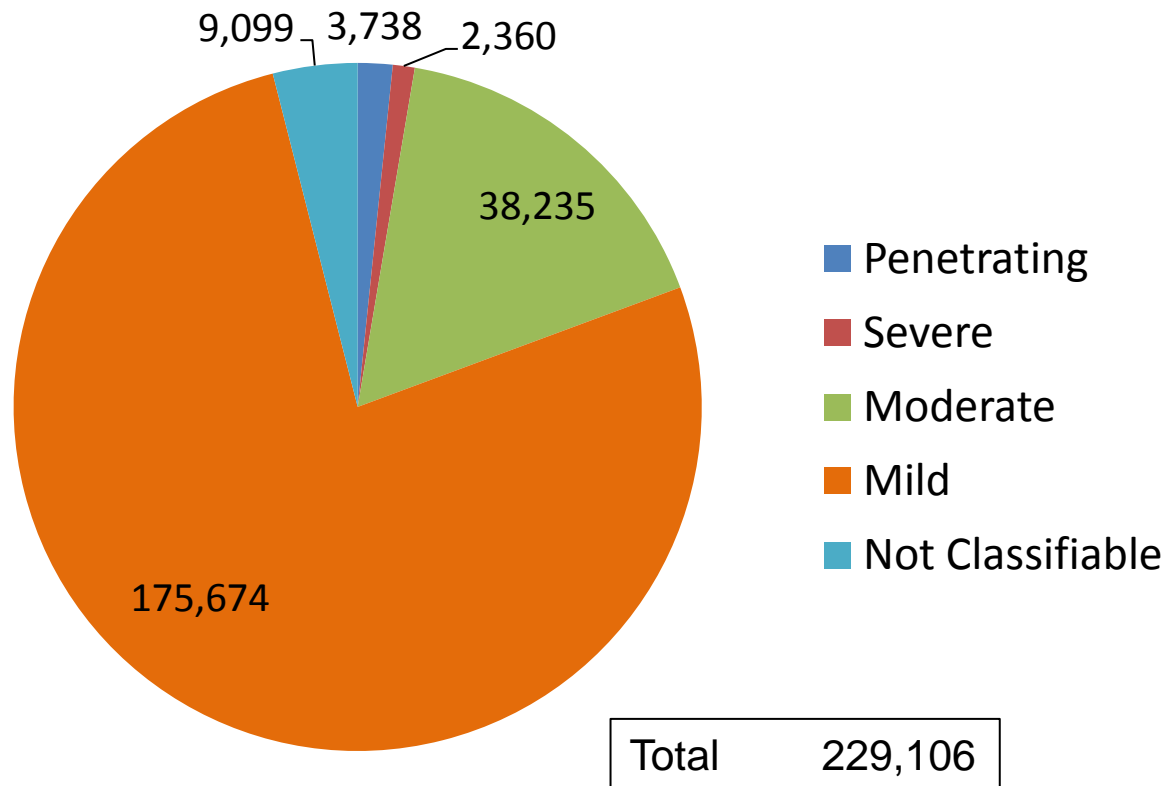
Primary: Direct exposure to over pressurization wave 40

IED: Improvised Explosive Device



TBI Numbers By Severity


DoD Numbers for Traumatic Brain Injury '00 – '11 Q3 Totals



Kandahar



MACE: Military Acute Concussion Evaluation



**Military Acute Concussion
Evaluation (MACE)**

Defense and Veterans Brain Injury Center

Patient Name: _____

SS#: _____ Unit: _____

Date of Injury: ____/____/____ Time of Injury: _____

Examiner: _____

Date of Evaluation: ____/____/____ Time of Evaluation: _____

History: (I – VIII)

I. Description of Incident
Ask:
a) What happened?
b) Tell me what you remember.
c) Were you dazed, confused, “saw stars”? ☐ Yes ☐ No
d) Did you hit your head? ☐ Yes ☐ No

II. Cause of Injury (Circle all that apply):
1) Explosion/Blast 4) Fragment
2) Blunt object 5) Fall
3) Motor Vehicle Crash 6) Gunshot wound
7) Other _____

III. Was a helmet worn? ☐ Yes ☐ No Type _____

IV. Amnesia Before: Are there any events just BEFORE the injury that are not remembered? (Assess for continuous memory prior to injury)
☐ Yes ☐ No If yes, how long _____

V. Amnesia After: Are there any events just AFTER the injuries that are not remembered? (Assess time until continuous memory after the injury)
☐ Yes ☐ No If yes, how long _____

VI. Does the individual report loss of consciousness or “blacking out”? ☐ Yes ☐ No If yes, how long _____

VII. Did anyone observe a period of loss of consciousness or unresponsiveness? ☐ Yes ☐ No If yes, how long _____

VIII. Symptoms (circle all that apply)
1) Headache 2) Dizziness
3) Memory Problems 4) Balance problems
5) Nausea/Vomiting 6) Difficulty Concentrating
7) Irritability 8) Visual Disturbances
9) Ringing in the ears 10) Other _____

08/2006 DVBIC.org 800-870-9244
This form may be copied for clinical use.
Page 1 of 6

- Developed by DVBIC and released in Aug 2006
- Performed by medical personnel
- 3-Part Screening Tool – “CNS”
 - Cognition
 - Neurological Exam
 - Symptoms
- Alternate versions available
- Upcoming revision will include recurrent concussion questions
- Can be used during exertional testing to ensure that cognitive function remains intact



- Objective: better inform return to duty determinations in the field following TBI beyond exertional testing and MACE
- NCAT
 - Over 450K baselines
 - Army ANAM Ops
- Vestibular Balance Plate Testing
 - Under development
- Nystagmus Detection
 - Under development

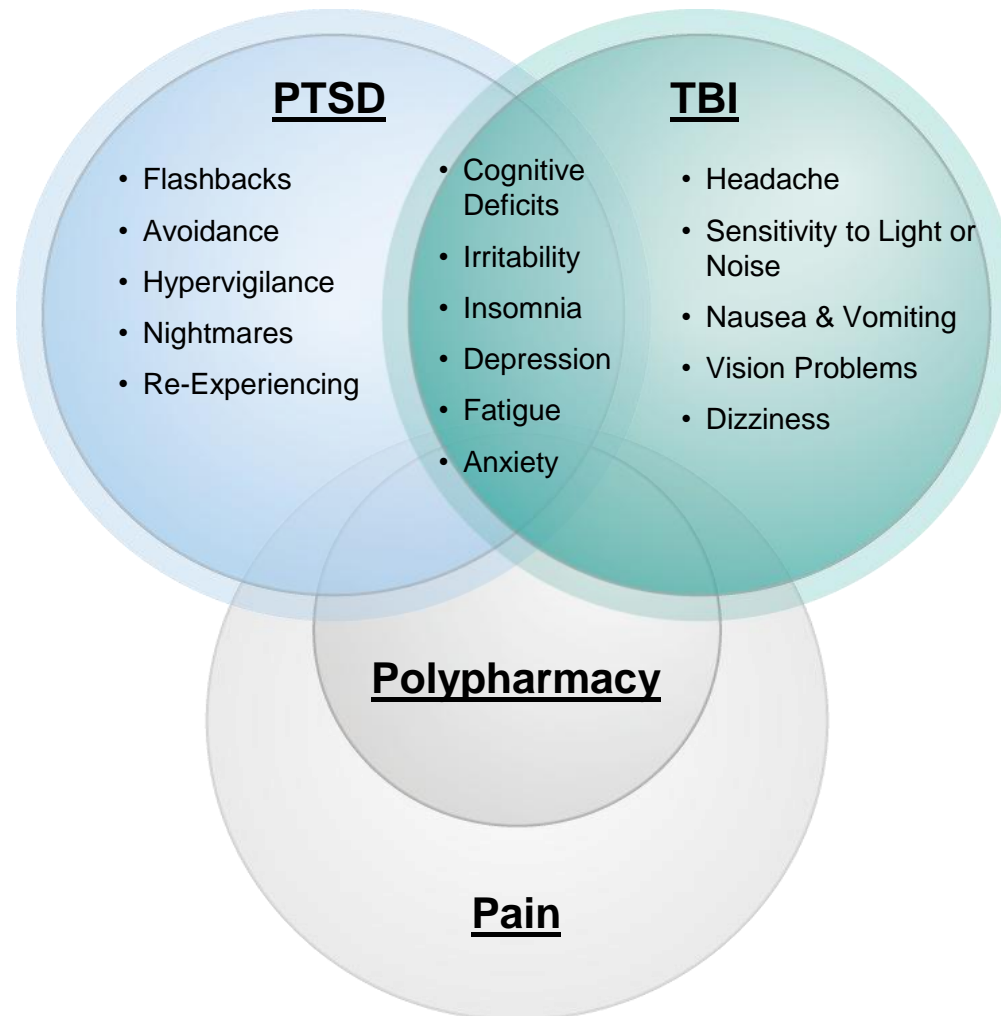
Palm Neurocognitive Test Field trials



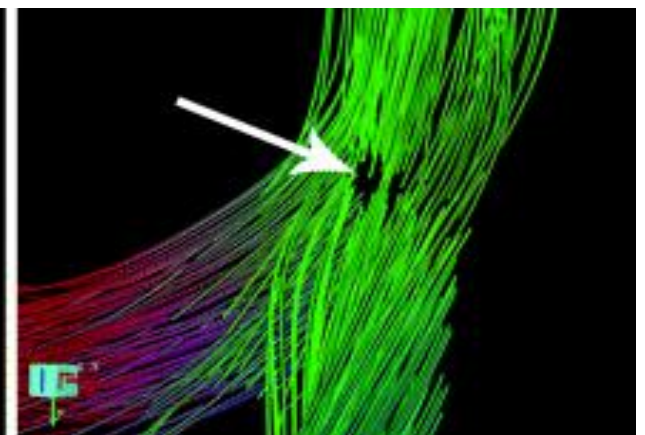
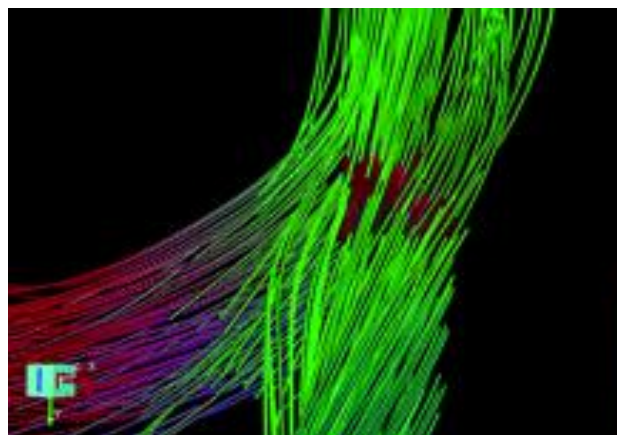
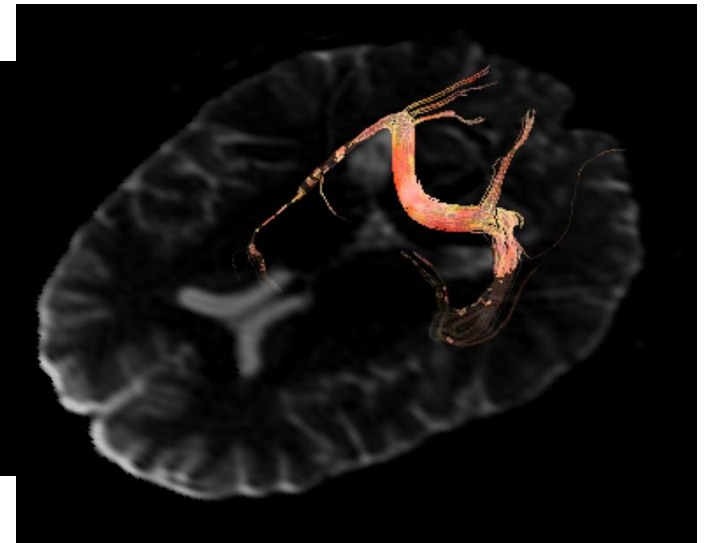
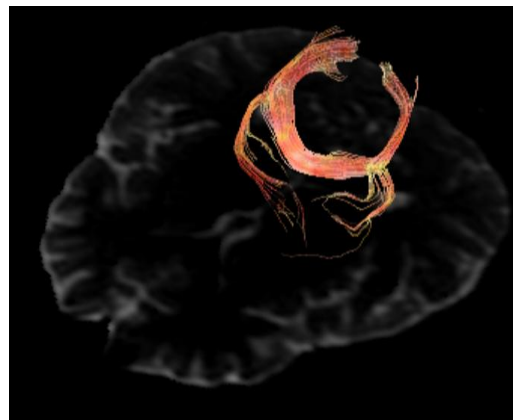
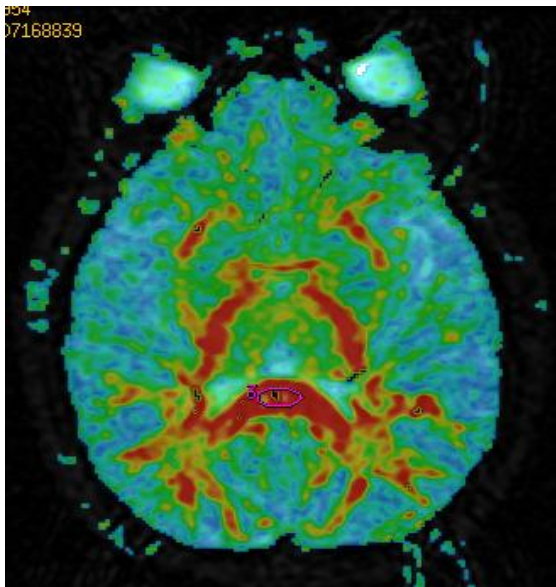


HNK - 1300
Capt - 30 Aug / 1300 - CHEST/ROCK
ENCLOSURE #601
550TR-01 SEP / 11APL
MURR-373
LT FRIEDMAN - 37th FLT SUI6@JF063MAJDM.WWV.SML.N/L
HMC TEDRICK
CS - MED 1
NET ID 927
TAC PHONE:
3693-116
NEXT TO LAST ROW 5TH TENT
0315
REPORTS W/NO DOC/LATE REPORTS/MISSING

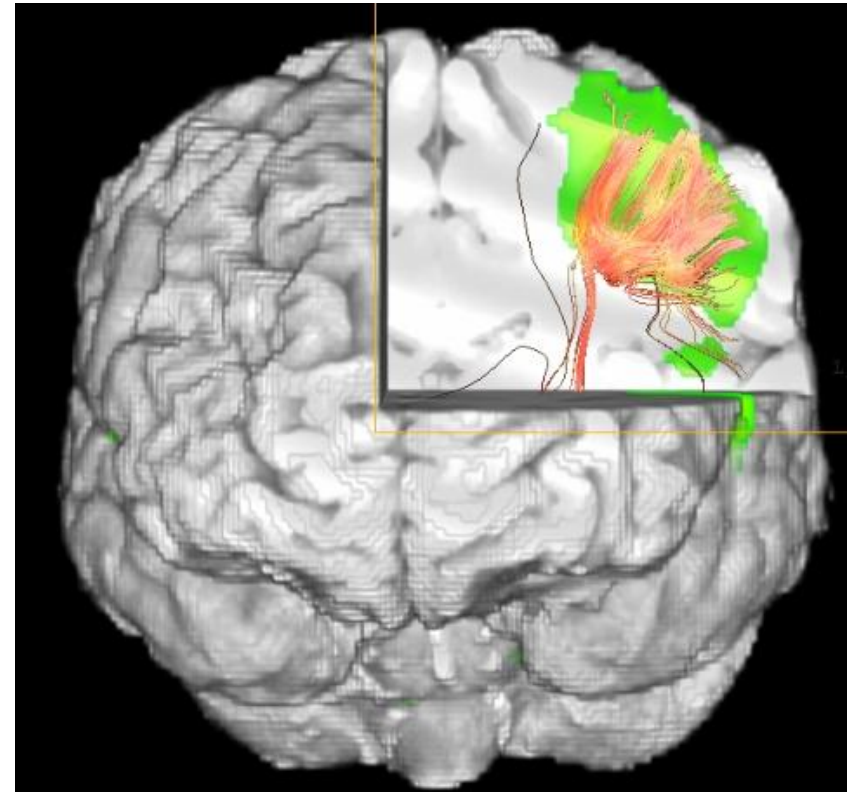
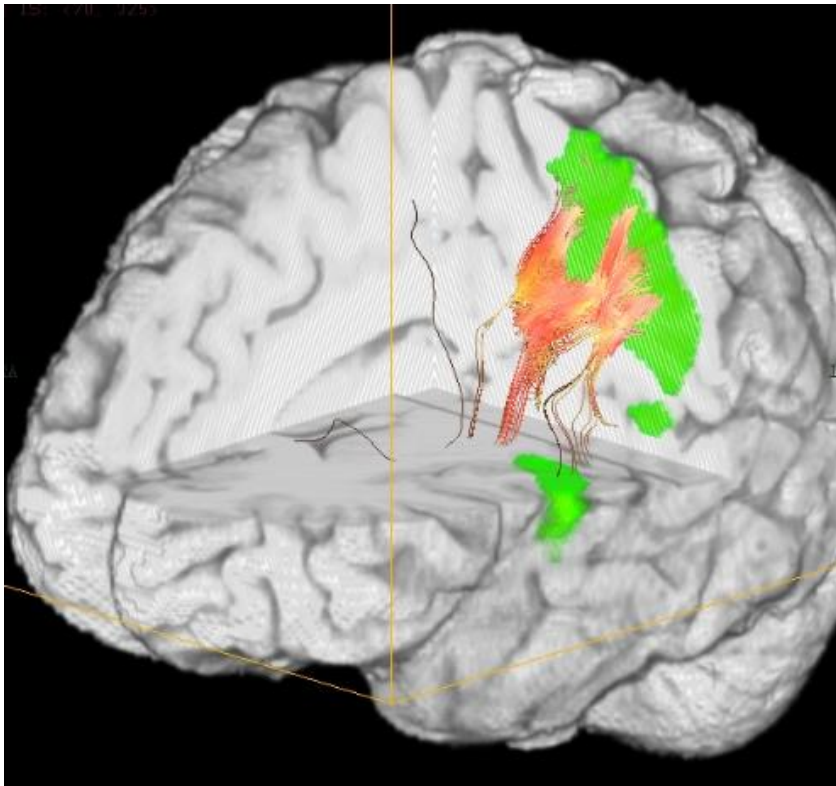
Medical Imperative: Challenging Co-morbidity



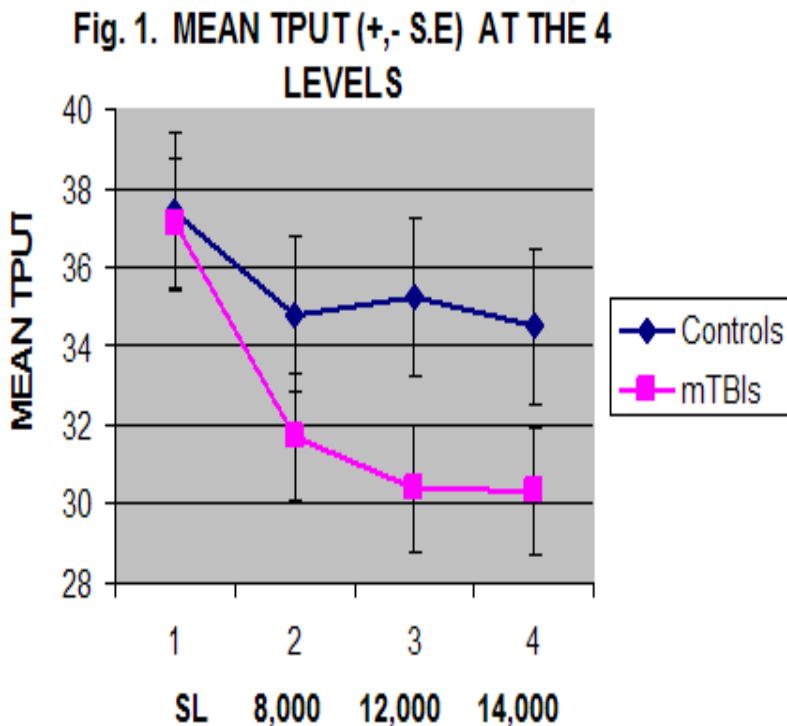
Corpus Callosum



Functional Connectivity



ANAM Matching to Sample (M2S; Memory Subtest)



- The performance decrements of mTBI (N=36) was over twice as great as the control (N=36). Note that at altitudes of 12,000 and 14,000, there is no overlap between the standard errors of the 2 groups.



Ribbon Cutting Ceremony 24 June 2010

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HRSA Grantee Technical Assistance
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